

Effect of Jigsaw vs. Traditional Group Work on 8th Graders' Basic Science Process Skills achievement in Laboratory

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Abstract

The purpose of this study was to explore the effect of Jigsaw-I model of cooperative learning (CL) on achievement of basic science process skills of 8th graders while working in science laboratory. An experimental study using randomized pretest posttest control group design was conducted. Sixty four male students were randomly selected from two intact 8th grade classes, 32 students from each class. Each group of thirty two students was further randomly assigned to experimental and control groups. Experimental group performed the experiments in science laboratory by using Jigsaw-I (JI) whereas control group performed the same experiments through traditional group work (TGW). "Basic Science Process Skills Laboratory Achievement-Tests (BSPSLAT-I & II)" were used as pre and post- tests to collect the data. The data was analyzed through independent sample t-test and ANOVA. The results showed significantly higher achievement of basic science process skills in favor of Jigsaw-I as compared to traditional group work. Moreover Jigsaw-I proved to be a better science laboratory technique both for low and medium achievers to gain basic science process skills. This study has implications for elementary science teachers to apply Jigsaw-I while science laboratory work for students' higher achievement in basic science process skills.

Keywords: Cooperative learning (CL), jigsaw-I (JI), traditional group work (TGW), basic science process skills, laboratory achievement test.

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Introduction

Procedural component of science involving science process skills is one of the most crucial components of science. The learning of science process skills is considered more important than theoretical knowledge of scientific facts, concepts and theories (AAAS, 1968). Science is all about what the scientists do, so the students should be required to learn “how to know” rather than “what to know” (Sheeba, 2013). Science process skills are defined as “a set of broadly transferable abilities, appropriate to many science disciplines and reflective of the behavior of a scientist” (Padilla, 1990). Science process skills not only serve as a crucial tool to learn science but also are one of the most important aims of science education (Afnidar & Hamda, 2015). Learning of science process skills prepare the students as future scientists, fulfills the goal of acquiring scientific literacy, enable the students to apply science skills to solve daily life problems (Ergul, Simsekli, Calis, Ozdilek, Gocmencelebi, & Sanli, 2011), develop students’ critical thinking and scientific inquiry skills (Sheeba, 2013) as well as provide them the opportunities to experience true nature of science. Improvement in science process skills expands student’s scientific knowledge, enhances achievement in science course (Feyzioglu, 2009) and opens the door for scientific discoveries and innovations.

Science process skills involve both cognitive & investigative skills including understanding of the method & procedure of scientific investigations. These skills are applied to collect knowledge, perform experiments, record & analyze data, and formulate results (Bilgin, 2006). Science process skills are either basic or integrated. The basic science process skills include “observing, classifying, measuring, using numbers, predicting and making conclusion” (Afnidar & Hamda, 2015, p. 169). These skills are advocated to teach right from elementary level which not only serves as a cognitive functioning foundation stage (Sheeba, 2013) but also paves the way to gain integrated science skills successfully at secondary level (Brotherton & Preece, 1995).

Most of students are found to exhibit inadequate science process skills in school science (Akani, 2015; Nnorom, 2016). Many students are reported to be unfamiliar of more than half laboratory apparatus and its use for different experiments (Ogundiwin, Asaaju, & Ojo, 2015). Inadequacies in science process skills not only lower down students’ scientific knowledge but also make them incapable to interpret the information, judge the evidences and draw conclusions. Therefore provision and improvement of students’ science process skills is the essential aim for all

the educational institutions (Bilgin, 2006). Laboratories are the special places which enable the students to execute and learn science process skills. According to Afnidar & Hamda (2015) students learn science skills effectively by working and performing science experiments in laboratory. A positive and linear relationship has been found between the science process skills and efficient use of laboratory (Feyzioglu, 2009). Feyzioglu (2009) further reported that “to equip the students with science process skills; laboratories must be efficiently used by teachers and students” (p.116). Research revealed that the inefficient use of laboratory do not improve science process skills (Hofstein & Naaman, 2007). Surprisingly laboratories are still not been used efficiently. Most of the laboratory working style is still of conventional nature involving inaccurate & insufficient laboratory methods (Chiappetta & Koballa, 2001), heavily loaded by teachers instructions, restricting students active participation, mutual sharing and thus is unproductive. In laboratories, most science teachers use large group demonstration method, some ask the students to work individually or in groups competitively (Hofstein & Naaman, 2007; Sahin-Pekmez, 2000). The use of these traditional methods and conservative laboratory environment leads to lower the learning of science process skills. Recent researchers have drawn attention towards the development of new approaches in laboratory work (Aydin, 2011). According to social constructivist view students in science laboratories should provide the opportunities to construct their own understanding about science concepts and science process skills (Hofstein & Lunetta, 2003). According to Hofstein & Lunetta (2003), “the science laboratory, a unique learning environment, is a setting in which students can work cooperatively in small groups to investigate scientific phenomena” (p.34). Ahuja (1994) reported that science components call for its learning through mutual cooperative efforts rather than through competitive or individual efforts.

The technique which fits to both the structural and functional nature of science, having rich theoretical bases and intensive research evidence in its favor is cooperative learning (CL). Cooperative learning is defined as “an instructional strategy in which students work actively and purposefully together in small groups to enhance both their own and their teammates learning” (Abrami, Poulsen, & Chambers, 2004, p.201). The five elements of CL i.e. face to face promotive interaction, individual accountability, positive interdependence, cooperative social skills and group processing (Jhonson & Jhonson, 1999) along with shared nature of goals, make CL a far more successful technique for the learning of science process skills than individual effort or traditional group work. During CL, students actively share & discuss their ideas, become

motivated and put more effort to achieve the shared goals. Positive interdependence triggers each group member to actively play their role to complete the assigned tasks. Individual accountability makes each group member responsible for his own learning thus each group member try to understand and perform the whole task.

In contrast to CL, during traditional group work (TGW), group members are neither made positively interdependent on each other for the completion of the group tasks, nor made individually accountable. As a result low skilled and shy students mostly remain passive and act as free riders whereas high skilled students dominate the group work causing rich getter rich effect. Sometimes the high ability students may lose their motivation due to passivity of other group members, they don't put their best and avoid completing the assigned task; the sucker effect (Johnson, Johnson & Smith, 2013). In contrast to traditional group work, CL efficiently avoids all these drawbacks. Johnson, Johnson, and Smith, (2013) reported that group work is only productive if it includes all the five elements of CL. According to Johnson & Johnson (1999) group work not including CL elements may hinder students' learning and cause dissatisfaction and tension among the group members which furthers lowers their learning and may also negatively affect their academic achievement. On the other hand, CL is found to enhance students' academic skills while working in science laboratory (Carpenter & McMillan, 2003). Working through rich cooperative interactions is one of the important conditions for effective learning in the laboratory, so students should work cooperatively in small groups to investigate scientific phenomena and learn science process skills during laboratory experiments (Hofstein & Lunetta, 2003). Cooperative learning methods have been found to improve science process skills both during class & laboratory experiments (Wachanga & Mwangi, 2004). The students who worked cooperatively in science laboratories were found to outperform in science process skills as compared to the students who worked in groups competitively, and as individuals (Okebukola and Ogunniyi, 1984 cited in Hofstein & Lunetta, 2003). So, CL seems to be a better technique both logically & literally for use in laboratory than TGW.

One of the most popular models of CL in science is Jigsaw-I which suits to the hierarchical structure of science. In Jigsaw, the meanings of different steps can be understood separately and then be put together like science (Lazarowitz & Hertz-Lazarowitz, 1998). Jigsaw-I makes each student to keenly teach and learn in expert groups and then to actively share their understandings to home groups and thus triggers each group member to play an active role in his learning (Jansoon, Somsook, & Coll, 2008).

Despite the rich research evidence in favor of Jigsaw-I for enhancing achievement of theoretical knowledge of science in classrooms (Cagatay & Demircioglu, 2013; Tarhana, Ayyildizb, Oguncb, & Sesenc, 2013), there is insufficient research towards the effect of Jigsaw-I on achievement of science process skills in laboratory (Winer, Chomienne, & Abad, 2000).

In Pakistani schools, the achievement of basic science process skills at elementary level is ignored. Science laboratory work is rare and in some schools where elementary students are provided chances to perform experiments in science laboratories, they perform through TGW which is not earning much in terms of students' achievement of basic science process skills. Most of elementary students are unaware of the laboratory apparatus & equipment (Aydin, 2011), unable to handle laboratory apparatus & perform experiments. They are deficient in the basic science process skills such as measuring, classifying, constructing hypothesis, recording data and drawing conclusions. The structural favorability of Jigsaw-I for learning science and rich research evidence in its favor to improve science achievement makes a strong case of Jigsaw-I use in science laboratory at elementary level to achieve basic science process skills. Therefore it was imperative to explore the effect of Jigsaw vs. Traditional Group Work on 8th Graders' Basic Science Process Skills achievement in Laboratory.

In order to explore the effect of Jigsaw-I on science process skills achievement; the following null hypotheses were tested:

H₀₁: There is no significant difference in the 8th graders' mean achievement scores for basic science process skills who worked in science laboratory through Jigsaw I than those who worked through TGW.

H₀₂: There is no significant difference in basic science process skills mean achievement scores between high, medium and low achievers who worked in science laboratory through Jigsaw-I

H₀₃: There is no significant difference in basic science process skills mean achievement scores between high, medium and low achievers who worked in science laboratory through TGW.

Methodology

A randomized pre-test post-test control group design was applied for this study. The subjects of the study were elementary students studying in a Govt. Higher Secondary School for Boys, Roshan Bheela, District Kasur. This school represents the typical Government school population including large class size, inadequate lab facilities i.e. insufficient apparatus &

chemicals, lacking of lab furniture, small laboratory size and students having difference in their socio-economic status and socio-cultural races.

The experimental and control groups used for this study were the randomly selected groups from two intact 8th grade classes, including 32 students from each class. Each group of thirty two students was further randomly assigned to experimental and control groups.

The experimental group had already twenty weeks' experience of learning science content through CL (STAD) in the science classroom, whereas control group had learned same science content for the same duration through traditional method.

A "basic science process skills laboratory achievement pre-test" (BSPSLAT-I) was taken individually from all the students of both the experimental and control group. After pre-test, both the experimental and control groups performed twelve science experiments which were selected from the General science textbook published by Punjab textbook board Lahore. Experimental group performed these experiments through Jigsaw-I whereas control group performed them through traditional group work (TGW). The study lasted for four weeks, thrice a week for one hour period per day. Both the experimental and control groups performed the same experiments in the same laboratory, on the same day but in two different periods of one hour. Except for the methodology of performing the experiments through Jigsaw-I vs. TGW; all the other variables including the experiments, duration of experimentation, laboratory facilities and teacher were kept same for both the experimental and control groups. Students of both groups performed science experiments under the facilitation of researcher who had served as a science teacher for ten years, currently is a teacher trainer and was well trained in different collaborative learning models. At the end of fourth week both the experimental and control groups were post-tested for BSPSLAT-II.

Instrumentation

In order to find out the difference in achievement of science process skills before and after performing laboratory experiments, two equivalent forms "Basic Science Process Skills Laboratory Achievement Tests" (BSPSLAT-I & BSPSLAT-II) were constructed by the researcher. BSPSLAT-I was used as pre-test whereas BSPSLAT-II was used as a post-test. Each test was consisted of twenty five multiple choice items. Each test included five subscales of basic science process skills i.e.

identification of laboratory apparatus & its use, observation, measurement, interpretation of tables and graphs, & drawing conclusions. These subscales were chosen on the basis of students' grade level and the kind of basic science process skills practiced to execute/perform selected experiments as per prescribed in the general science textbook/syllabus. Firstly a pool of eighty items was developed. These items were first judged by three elementary science teachers and then by two experts in the field of science education. Twenty items (25%) were dropped as a result of judgmental validity. Then the remaining sixty items were distributed to pre and post-test in such a way that both the tests were equated. For the pilot testing these tests were applied to twenty 8th graders other than the sample of this study. At this stage ten items (five from each test) which had low reliability were excluded. Thus the final form of each test included twenty five items. The Cronbach's Alpha reliability for BSPSLAT-I&BSPSLAT-II was .85 & .84 respectively which gave a robust reliability to both the tests.

Procedure

First day a pre-test (BSSLAT-I) was taken from 8th graders of both the experimental and control groups on same day and time. On the basis of pre-test result high, medium and low achievers in science process skills were identified from both the experimental and control groups as prescribed by Slavin (2013). Out of 32 students of experimental group, eight high, sixteen medium and eight low achievers were randomly allocated to eight heterogeneous Jigsaw-I: home groups, in such a way that each home group was comprised of one high, two medium and one low achiever. Same procedure was applied for control group thus making the groups size and composition same for both the experimental and control group.

Second day the researcher took the students of experimental and control groups to laboratory and get them aware of the availability of laboratory facilities i.e. equipment & apparatus, chemicals, water, electricity, furniture. On third day, the experimental and control groups started to perform science experiments in laboratory. Both the groups performed the same experiment on same day in the same laboratory.

Experimental Group

In experimental group, Jigsaw-I was applied by assigning four members of each home group different roles of leader, reader, performer

& recorder. Each home group was asked to assign these roles to its team members after the group consultation. The detailed account of these group members' roles is shown in table 1 as under:

Table 1

Description of Roles of Jigsaw-I Group Members

Sr.#	Roles	Description of roles
1	Group Manager	<ul style="list-style-type: none"> • Identify and manage apparatus & chemicals • Manage group processing • Time management for completion of the experiment in group
2	Reader	<ul style="list-style-type: none"> • Read the precautionary measures related to experiments • Read and understand the given manuscript of step by step procedure of relevant experiment
3	Performer	<ul style="list-style-type: none"> • Set the apparatus • Perform the experiment
4	Recorder	<ul style="list-style-type: none"> • Draw tables/record data • Conclude the findings • Interpret the results

On the basis of above group member roles of home groups, eight expert groups; two of the “Group Managers”, two of “Readers”, two of “Performers” and two of “Recorders” were formed for all the selected experiments. Each expert group was provided the relevant manuscript. The group managers were provided the list of apparatus and chemicals and asked to identify the apparatus, equipment and chemicals needed to complete the particular experiment. The readers were given detail of precautionary measures and procedural steps and asked to understand the specific precautions for the experiment and the step by step procedure of the experiment. The performers were provided the diagram of set apparatus and asked to learn how to set the apparatus. The recorders were provided data recording instructions & tabular patterns and asked to understand how to draw the relevant tables and to tabulate, record the data and interpret the results. For each experiment, members of all the expert groups were given twenty minutes to share and complete their relevant tasks. Then they returned back to their home groups and shared their learning with the home group members. In next forty minutes each home group set the apparatus, performed the experiment, recorded data and drew the conclusions.

Control Group

On the other hand, eight “traditional working groups” of control group were not allocated specific roles. All traditional working groups were given same manuscript as to experimental group and asked to first share their knowledge & understanding about the apparatus, chemicals, procedure, apparatus setting, data recording & conclusion drawing for first twenty minutes and then to set the apparatus, perform the experiments, record data and draw conclusions within next forty minutes.

The researcher role in the study was to make sure about availability of all the required resources such as equipment, apparatus and chemicals, water & electricity supply and furniture, to provide the manuscripts of the selected experiments, to assure their safety during experimentation & to cope with any of the accidental situation, and to facilitate both the experimental and control group students during working in relevant groups only when she was called for it by any of the group, other than that no extra assistance was provided to either group.

At the end of four weeks SPSLAT-II was taken individually from all the students of both experimental and control groups on same day and time.

Results of the Study

The results of the study were divided into two parts:

Part a: To investigate the difference in the 8th graders' achievement of basic science process skills who worked in science laboratory through Jigsaw-I vs. TGW, independent sample t-test was applied separately on the mean scores of both the groups for SPSLAT-I & SPSLAT-II.

Part b: To explore the difference in basic science process skills achievement between high, medium and low achievers worked in science laboratory through Jigsaw-I vs. high, medium and low achievers worked through TGW, one way analysis of variance (ANOVA) was separately applied on the high, medium and low achievers' mean scores of both the comparison groups for SPSLAT-II.

Part a: Effect of Jigsaw-I on Achievement of Basic Science Process Skills

H₀₁: There is no significant difference in the 8th graders' mean achievement scores for basic science process skills who worked in science laboratory through Jigsaw I than those who worked through TGW.

Table 2

Results of the Independent Sample t-test for SPSLAT-I & SPSLAT-II

Dependent variable	Groups	N	Mean	SD	df	t-value	P
SPSLAT-I Pre-test	Jigsaw-I	32	10.69	2.84	62	.450	.654
	TGW	32	10.38	2.70			
SPSLAT-II Post-test	Jigsaw-I	32	17.38	2.78	62	5.01	.000*
	TGW	32	13.50	3.37			

*p<0.01

Table 2 depicts that for BSPSLAT-I, the difference between mean achievement scores of groups who worked in science laboratory through Jigsaw-I vs. TGW was not statistically significant (t-value=.450, p=.654). It is evident that both groups were almost same on basic science process skills' achievement prior to the execution of the study. Whereas for BSPSLAT-II, there was statistically significant difference between mean scores of groups who worked in science laboratory through Jigsaw-I than those who worked through TGW in favor of Jigsaw I (t-value=5.01, p=.000). So the null hypothesis is rejected and it is evident that 8th graders who worked in science laboratory through Jigsaw-I achieved significantly higher on SPSLAT-II as compared to TGW.

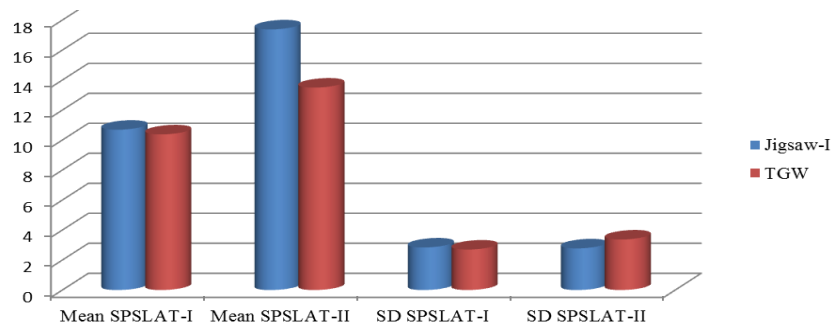


Figure 1: Graphical Illustration of Mean Achievement Scores & SD on Jigsaw-I vs. TGW for SPSLAT-I & SPSLAT-II

Part b: Effect of Jigsaw-I on Achievement of High, Medium and Low Achievers in Basic Science Process Skills

H₀₂: There is no significant difference in basic science process skills mean achievement scores between high, medium and low achievers who worked in science laboratory through Jigsaw-I

H₀₃: There is no significant difference in basic science process skills mean achievement scores between high, medium and low achievers who worked in science laboratory through TGW.

Table 3

Results of ANOVA for Mean Scores Comparison between High, Medium & Low Achievers of Jigsaw-I vs. TGW on BSPSLAT-II

Groups	Sub-Groups	Mean	SD		Sum of Squares	df	Mean Square	F	Sig.
Jigsaw-I	High	18.63	3.50	Between Groups	34.19	2	17.09	2.41	.107
	Medium	17.56	2.33	Within Groups	205.31	29	7.08		
	Low	15.75	2.31	Total	239.50	31			
TGW	High	15.50	1.85	Between Groups	114.75	2	57.38	8.44	.001*
	Medium	13.63	3.13	Within Groups	197.25	29	6.80		
	Low	10.25	1.90	Total	312.00	31			

*p<0.01

Table 3 shows that for BSPSLAT-II, the mean achievement scores between high (M=18.63, SD=3.50), medium (M=17.56, SD= 2.33), and low achievers(M=15.75, SD= 2.31) who worked in science laboratory through Jigsaw-I were not significantly different (F=2.41, p=.107) whereas there was significant difference between the mean achievement scores of high (M=15.50, SD=1.85) medium (M=13.63, SD= 3.13) and low achievers (M=10.25, SD=1.90) who worked in science laboratory through TGW (F=7.69, p=.001) at p<0.01. Based on the results H₀₂ is accepted and H₀₃ is rejected.

Post Hoc was further carried out separately to investigate the groups' (high, medium and low achievers) differences in the mean achievement scores who worked through Jigsaw-I vs. TGW.

Table 4

Post Hoc (Scheffe) Comparison for Sub-groups' Mean Scores on BSPSLAT-II

	Groups	Group I (High)	Group II (Medium)	Group III (Low)
Jigsaw-I	Group I (High)		.658	.115
	Group II (Medium)	.658		.305
	Group III (Low)	.115	.305	
TGW	Group I (High)		.268	.002*
	Group II (Medium)	.268		.020*
	Group III (Low)	.002*	.020*	

* $p < 0.01$

Table 4 revealed that the mean achievement scores of high achievers who worked through Jigsaw-I was not significantly different from medium achievers ($p=.658$) and low achievers ($p=.115$). Similarly the mean achievement scores of medium achievers is not significantly different from low achievers ($p=.305$). In contrast for TGW, although there was no significant difference between the mean achievement scores of high and medium achievers ($p=.268$) but the mean achievement score of high achievers was significantly different from low achievers in favor of high achievers ($p=.002$). Similarly significant difference was established in the mean achievement scores between medium and low achievers in favor of medium achievers ($p=.020$).

It is evident that the medium and low achievers of TGW did not improve their basic science process skills' achievement and retained at medium and low level. In contrast the medium and low achievers of Jigsaw-I significantly enhanced their basic science process skills achievement level almost close to the level of high achievers. The results revealed the supremacy of Jigsaw-I over TGW to enhance the science process skills achievement while working in science laboratory.

Conclusion and Discussion

Results of the present study show that the experimental group who worked in laboratory through Jigsaw-I achieved significantly higher in basic science process skills than the control group worked through TGW. It is concluded that Jigsaw-I proved to be a far better science laboratory technique at elementary level as compared to the TGW to achieve high in basic science process skills. Moreover Jigsaw-I was found to be more effective laboratory technique both for medium and low achievers to achieve basic science process skills than TGW. The results of the study are aligned with the few studies conducted so far in this respect such as Saleh (2011) has also reported the positive effect of Jigsaw on the achievement of science process skills. Aksoy & Doymuş (2011) found that that CL is more effective method than traditional teaching to learn the laboratory skills for 6th graders. Jigsaw was also reported to significantly improve the laboratory skills of university students than traditional group method (Aydin & Biyikli, 2017) and significantly enhance the science process than confirmatory laboratory method (Karacop & Diken, 2017). Although the research on the effect of Jigsaw on science process skills is rare but the positive effect of different models of CL like learning together & group investigative models on science practical performance in laboratory has been proved by a number of studies (Díaz-Vazquez, et. al.2012; Koc, Okumus, Ozturk, 2013; Ogundiwin, Asaaju, Adegoke, & Ojo, 2015). The performance in laboratory experiments is directly related to the exhibition of science process skills as “through experiments students develop their skills and knowledge in hand skills, research, hypothesis construction, variable identification, problem solving, running experiments, making observations and inferences, application, analysis and synthesis and scientific interpretation, (Aydin, 2011; p.637). So the present study is in line with previous research.

In Pakistan, at elementary level the acquisition of basic science process skills is not yet given due importance. Also the evaluation of basic science process skills through laboratory experiments is altogether absent. The Punjab education commission (PEC) public school annual examination for 5th & 8th grade as well as private schools examinations only involve the testing of science concepts rather than evaluation of basic science process skills. However some of the schools arrange laboratory experiments to enhance elementary student's basic science process skills but only via TGW and not through CL innovative models like Jigsaw-I. The significantly higher mean scores of experimental

group on achievement of basic science process skills than control group proved Jigsaw-I a far better laboratory technique than the TGW.

Moreover students who worked in science laboratory through Jigsaw-I, were found to be more disciplined, showed vigilance in shifting between home & expert groups, exhibited more confidence in handling laboratory apparatus and enjoyed more as compare to control group students who worked in traditional groups. For experimental group, exposure to Jigsaw-I was their first experience which reveals that CL innovative models like Jigsaw-I need to make their roots in Pakistani school science laboratory. Thus the Jigsaw-I strategy is recommended to use in science laboratories to enhance the achievement in basic science process skills at elementary level.

This study provided the empirical evidence of effectiveness of Jigsaw-I in school laboratories which may convince and motivate elementary science teachers to use Jigsaw-I in science laboratories. There is also need to train both pre-service & in-service science teachers to know, understand and apply Jigsaw-I in the laboratories. The researcher found inadequate laboratory apparatus to conduct either Jigsaw-I or TGW and has to manage most of the apparatus & equipment and chemicals herself. Moreover laboratory facilities such as availability of electricity & light were not satisfactory. Which revealed that to take initiative for converting traditional laboratory methods to innovative one, the laboratory conditions must be improved. This study also adds to the global discussion on the effect of Jigsaw-I towards enhancing science process skills in laboratory.

This is a preliminary study in Pakistani context including elementary boys of a rural public school. Further studies need to be conducted on both public & private students of urban areas. Moreover future studies should also be conducted including female students. An action research is further needed to find out the causes of not using innovative laboratory techniques like Jigsaw-I in Pakistani schools. Also future studies are required to explore the effects of Jigsaw-I and other CL methods like learning together & group investigation on both basic & integrated science process skills vs. TGW at different grade levels.

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